Prediction of Workpiece Location Due to Fixture-Induced Error

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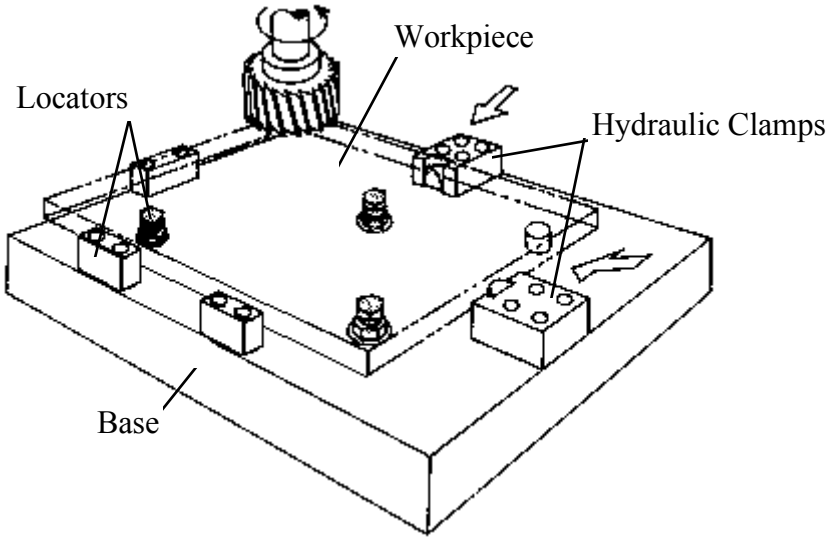
Outline:

- Project goal
- Prior work
- Model components
- Model integration
- Initial results
- Summary and next steps



Basic 3-2-1 Fixturing scheme

Project goal:

Fixtures are a critical component of the manufacturing system, they serve to repeatedly and uniquely locate and hold a workpiece. Fixture induced errors such as:

- Clamp, locator, workpiece bulk deformation
- Locator and workpiece geometry error
- Clamping sequence

, all effect workpiece fixturing error.

Our goal is to model these error sources to better understand their effect on the final position and orientation of the workpiece

Application:

- Fixture design
- Tool path and assembly trajectory planning/correction
- Tolerance allocation

Prior Work:

Author	Primary focus	Limitation
DeMeter	Simoltaneous solution with locator error	Rigid workpiece and locator, no clamping effects
Salisbury	Sequential solution with locator & wrkpc error	Rigid workpiece and locator, no clamping effects
DeVor	Modeling of effect of clamping sequence	Error in locator or workpiece geometry not modeled
Melkote	Localized contact deformation model	No bulk deformation of system, workpiece position not effected

Our model's limitations:

-Prismatic workpieces

-3-2-1 locating scheme (can be extended with modifications)

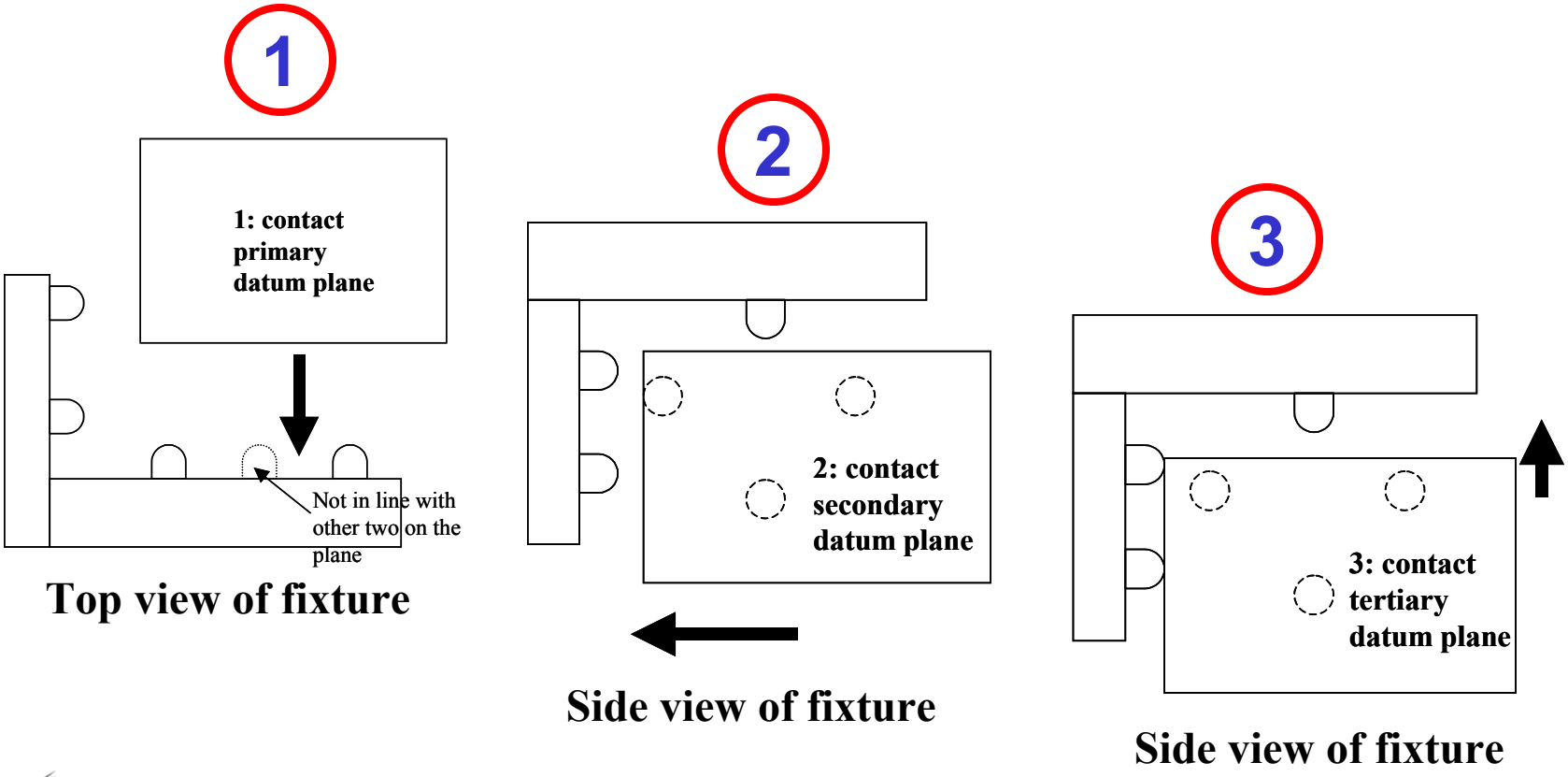
-Limited clamping locations

-Re-run FEA to generate flexibility influence coefficients

Model components: workpiece placement

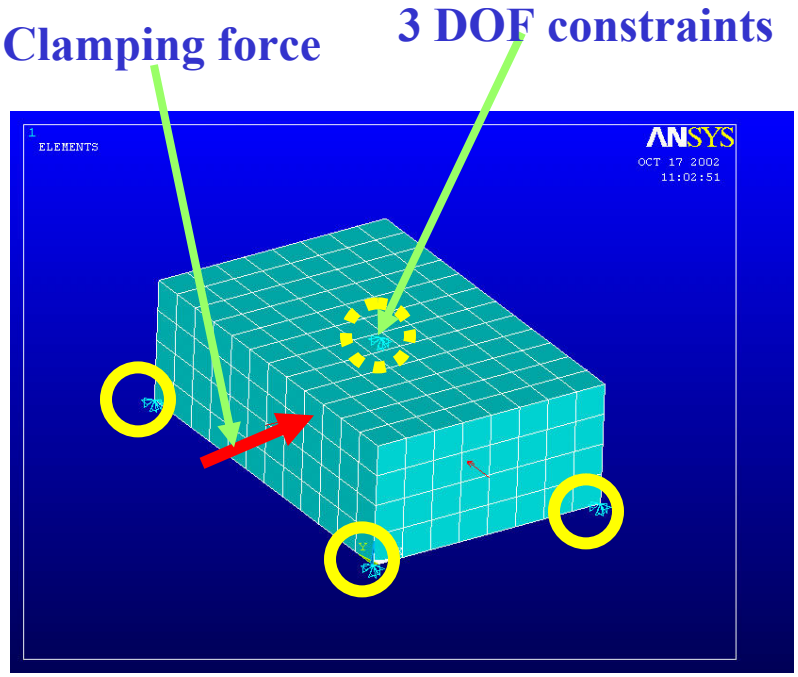
- Uses sequential positioning

- Motion through series of translations and rotations



Bulk deformation model: workpiece

- Simple model in ANSYS to determine flexibility influence coefficients
- Points are constrained at base corners of workpiece



Basic model

$$\begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \\ c_{31} & c_{32} & c_{33} \end{bmatrix} \begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix}$$

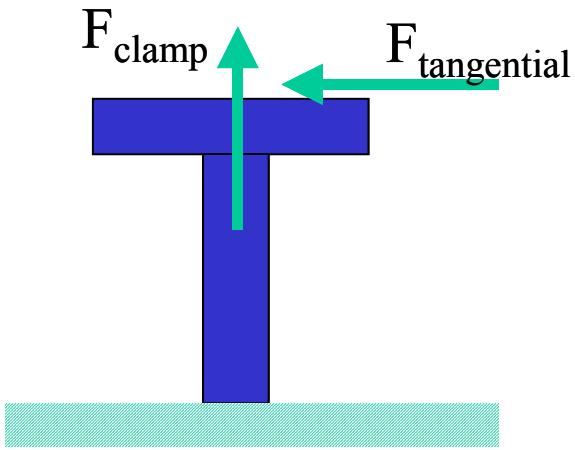
c_{ij} : flexibility influence coefficient

Flexibility influence coefficient matrix for a 3 DOF system

Bulk deformation model: clamp and locator

Clamp bending:

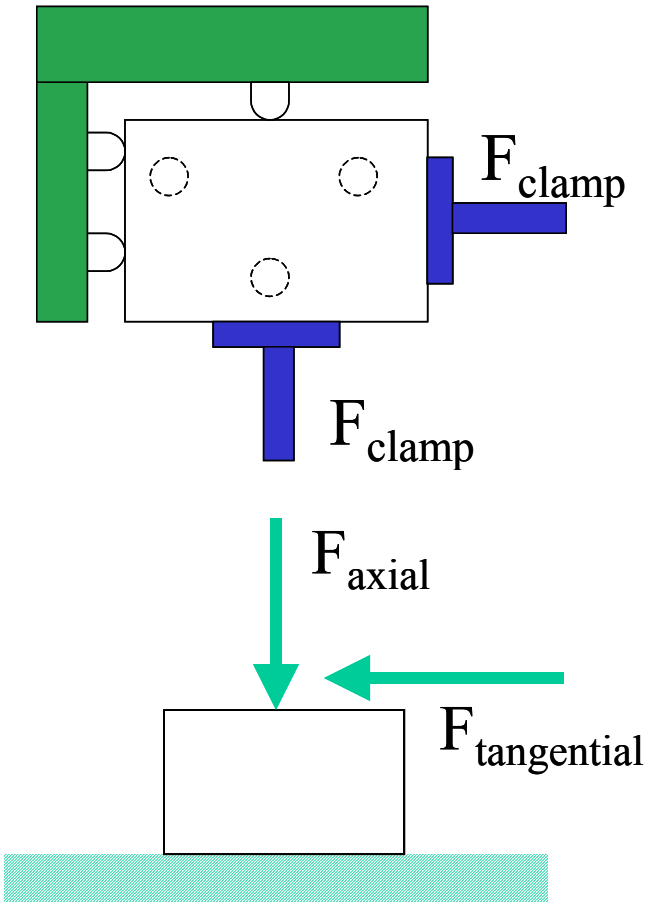
(beam model)



Locator bending:

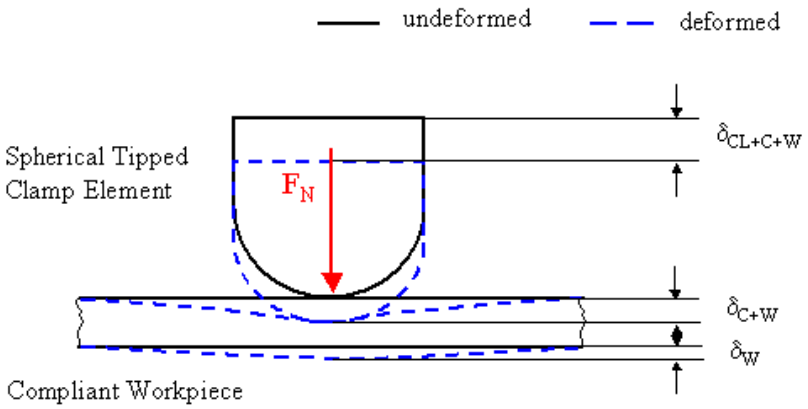
(short stubby beam model)

Fixture layout (top view)



Local deformation and clamping sequence

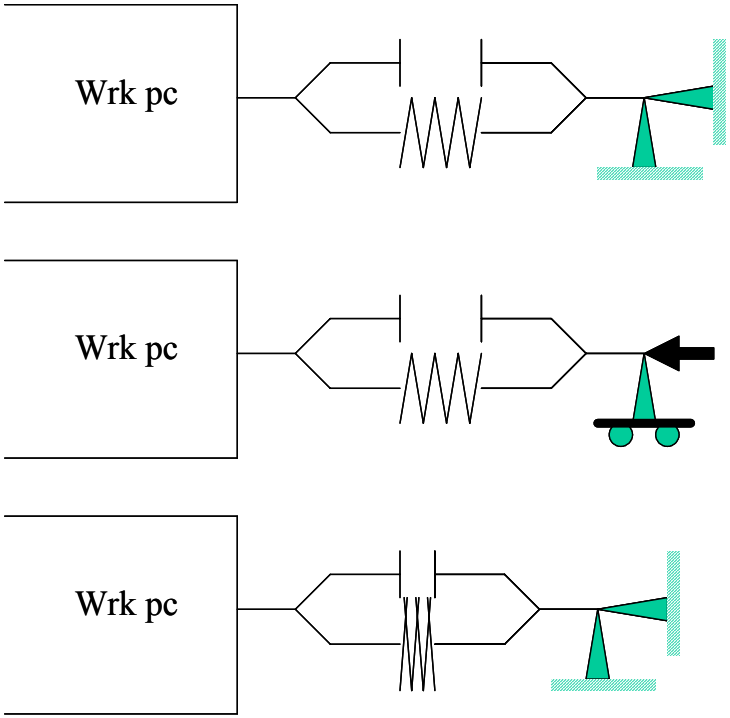
Localized deformation model developed by Satyanarayana and Melkote



Contact deformation

(S. Sathyanarayana thesis, 2001)

Clamping sequence model By Chandra and DeVor



Model integration

Input conditions

↓

Determine deformation magnitudes

↓

Sum geometric and deformation error

↓

Determine final position and orientation of workpiece

Initial conditions

- Clamping forces
- Workpiece geometry
- Locator positions
- Clamping positions

Deformation calculation:

Minimization of system energy method

Error modeling:

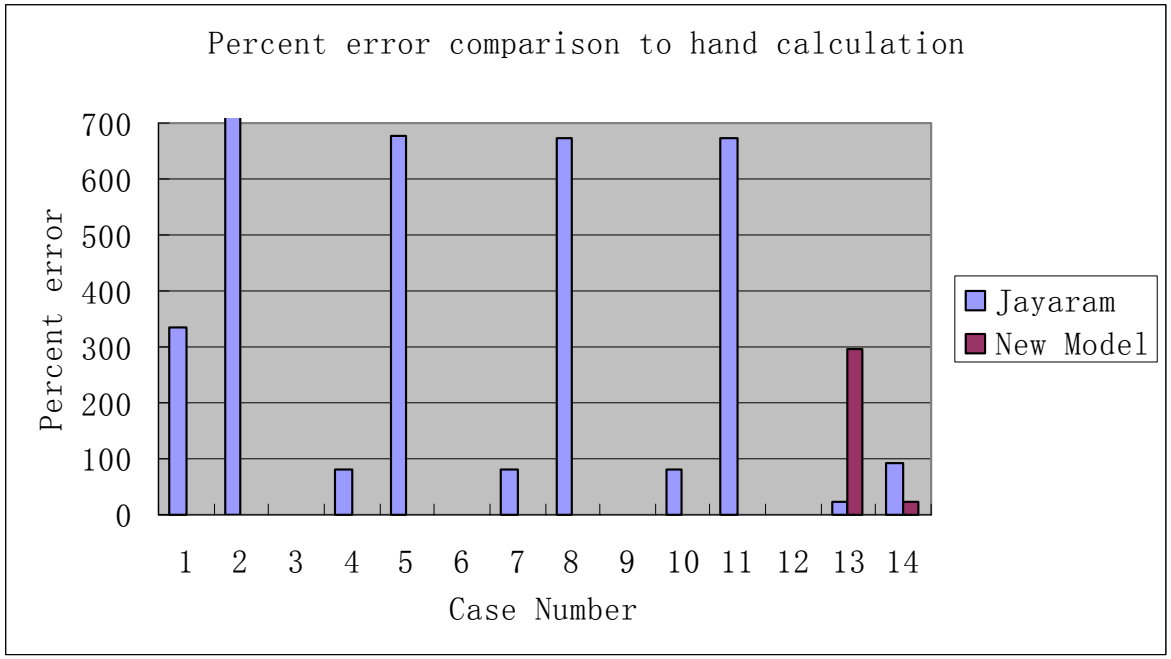
$$E_{total} = E_{geometry} + E_{deformation}$$

Initial results

Workpiece dimensions
x, 12 units
y, 12 units
z, 2 units

Point	Coordinate
Point 1	(4, 4, 0)
Point 2	(16, 16, 2)

	KEY	
Case 1	Translation A	Point 1
Case 2	Translation A	Point 2
Case 3	Translation B	Point 1
Case 4	Translation B	Point 2
Case 5	Translation C	Point 1
Case 6	Translation C	Point 2
Case 7	Translation D	Point 1
Case 8	Translation D	Point 2
Case 9	Rotation A	Point 1
Case 10	Rotation A	Point 2



Summary and next steps

- Presentation of goal
- Description of model and components
- Model integration
- Initial results

Next steps:

- Generate alternative flexibility influence coefficients
- Integration of entire model
- Validation through experimental testing

Questions